Phase light curves of Earth-like planets

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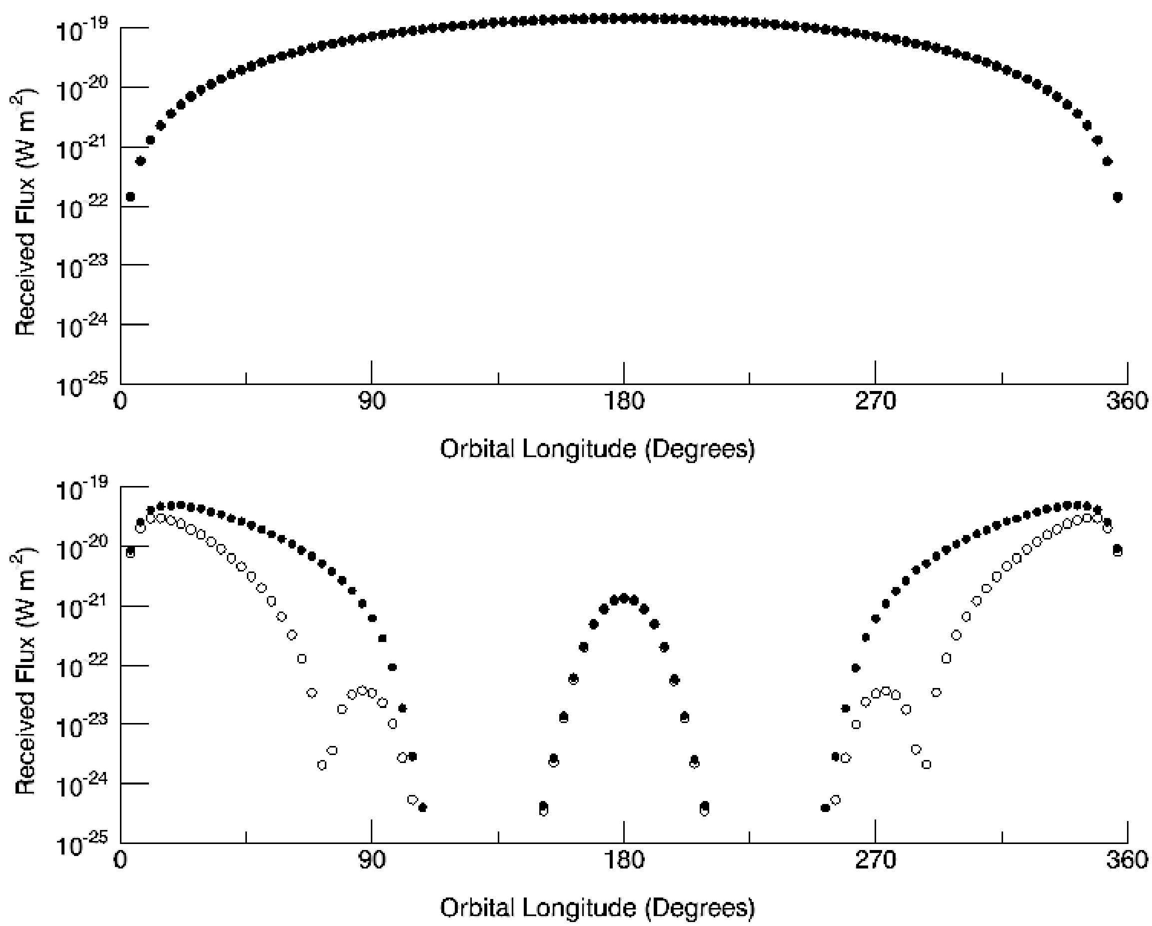
We present model calculations of the phase (orbital) light curves of Earth-like planets at visible and infrared wavelengths. Rotationally-averaged infrared light curves are calculated by geometrically projecting the outgoing IR flux from energy balance models that include meridianal heat transport and finite thermal inertia. The models are calibrated using the surface temperature distribution of the Earth. Visible light curves are calculated using a geometric optics model that includes specular and diffuse scattering by oceans and land surfaces. A statistical scattering model of the ocean surface uses previously derived empirical formulas. For ocean scattering, the polarizations perpendicular and parallel to the star-planet bisector are treated separately. We find that a global ocean has a profound effect on both light curves: The thermal inertia of the ocean mixed layer damps the otherwise large amplitude signal of a planet with seasons. Oceans contribute to polarization of the visible signal and change the orbital phase of maximum signal by 180 degrees. The figure shows the visible light curves for two planets on edge-orbits; the top one with a Lambertian surface and albedo of 0.5; the bottom one with a global ocean, no land surfaces or clouds, and calm winds. In the latter, the parallel polarized flux is plotted as filled points and the perpendicular polarized flux as open points. Variable obliquity, cloudiness, and land fraction confuse or attenuate the effects of a global ocean and combined infrared and visible light curve data are important to detect oceans and habitable surface conditions on terrestrial planets.



Received Flux (W m^{-2})
10^{-19}
10^{-20}
10^{-21}
10^{-22}
10^{-23}
10^{-24}
10^{-25}
0
90
180
270
360
Orbital Longitude (Degrees)